

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SOME LIFT AND DRAG MEASUREMENTS OF A  
REPRESENTATIVE BOMBER NACELLE ON A LOW-DRAG WING

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CONFIDENTIAL BULLETIN

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SOME LIFT AND DRAG MEASUREMENTS OF A  
REPRESENTATIVE BOMBER NACELLE ON A LOW-DRAG WING

By Macon C. Ellis, Jr.

SUMMARY

Tests of a representative bomber nacelle on a low-drag wing were made in the NACA two-dimensional tunnel. Results show the adverse or interference effects of the nacelle on the low-drag wing to be small.

INTRODUCTION

An investigation of a series of radial-engine nacelles on a thick low-drag wing has been made in the NACA 8-foot high-speed wind tunnel. The results of these tests show that the drag is low for certain nacelles and that the lift of the wing is not seriously affected by the nacelles.

Under conditions of low turbulence, however, questions have continued to arise concerning possible adverse effects of conventional nacelles on low-drag wings. A program of tests was therefore begun of several typical manufacturers' nacelles, mounted first on a moderately thick NACA 66-series wing in the NACA two-dimensional wind tunnel.

The use of the NACA two-dimensional wind tunnel, which has an air stream of very low turbulence, made the investigation possible at large values of the Reynolds number. At the present time, emergency conditions necessarily limit the scope of the tests, but it is hoped that the results of these nacelle tests will be of sufficient value to warrant more thorough investigations of proposed military models of immediate interest.

DESCRIPTION OF MODEL

The 1/10-full-scale model nacelle (figs. 1, 2, and 3) was built from North American Aviation, Inc. drawings



of a proposed two-engine bomber. Some modifications during construction were suggested by Mr. William Wheeler, representative of North American Aviation, Inc. at the Laboratory. No drawings for the shape of the carburetor inlet were available; the shape of the inlet on the model was based on a given area of 80 square inches full scale. The air taken in through this inlet was exhausted at the tail of the model. The model nacelle tested was first mounted on an NACA 66,2-216,  $\alpha = 0.6$ , wing having a chord of 15 inches and a span of 3 feet (tunnel test-section width). The wing was set at the theoretical ideal angle for the wing section, which in this case is 31 minutes in a positive direction from the center line of thrust of the nacelle. In order to evaluate the interference effects a second test was made with the model nacelle mounted on a 6-inch-chord symmetrical wing, 12.5 percent thick (fig. 3).

The baffle plate in the model was designed for a  $\Delta p/q = 0.58$ , which represents a pressure drop through the engine of  $\Delta p = 19$  inches of water at 392 miles per hour at an altitude of 25,000 feet. The pressure drop at the cowl exit actually obtained in the tests was  $\Delta h/q = 0.40$  at the design angle.

#### TEST METHODS<sup>1</sup>

Drag measurements were obtained by making wake surveys at a series of spanwise stations. Points were taken far enough outside the nacelle disturbance to establish the section drag of the wing. The integral of this curve (fig. 4) above the section drag of the wing was then taken as the total additional drag of the nacelle. Internal-drag measurements were made by making total head and static pressure measurements in the exits. The method for calculating the drag due to the internal losses is given in reference 1. The external drag is then the total additional drag minus the drag due to internal losses. The external-drag coefficient  $C_{D_F}$  is based on the frontal area of the nacelle.

#### RESULTS AND DISCUSSION

Values of  $C_{D_F}$  for the nacelle under various conditions are given in figure 5. At the design angle, the drag decreased with the addition

<sup>1</sup>At the time this report was originally published, some of the corrections required for reducing the test data to free-air conditions had not been determined. The values of section lift coefficient  $c_l$  (fig. 6) should be corrected by the following equation

$$c_l(\text{corrected}) = 0.965c_l + 0.006$$



of ordinary tapered fillets from  $C_{Df} = 0.055$  to  $C_{Df} = 0.041$  at a Reynolds number of  $3.1 \times 10^6$ . Unfortunately, owing to limited testing time, no other tests were made without fillets. At a Reynolds number of  $6.5 \times 10^6$ , however, the drag with fillets increased to only  $C_{Df} = 0.045$ . This value indicates that there might still be a reasonable reduction in drag through the use of fillets at larger values of the Reynolds number. Sealing the accessory compartment exit slot (fig. 1) produced an increase in drag.

Values of  $C_{Df}$  for the nacelle mounted on the 6-inch-chord wing of conventional section show the drag to be slightly higher than for the nacelle on the low-drag wing. From this comparison, and from the fact that all the values of  $C_{Df}$  are low, it seems reasonable to say that the adverse effects of the nacelle on the low-drag wing are small. Other tests in the two-dimensional tunnel of different nacelles on the same low-drag wing show substantially the same results.

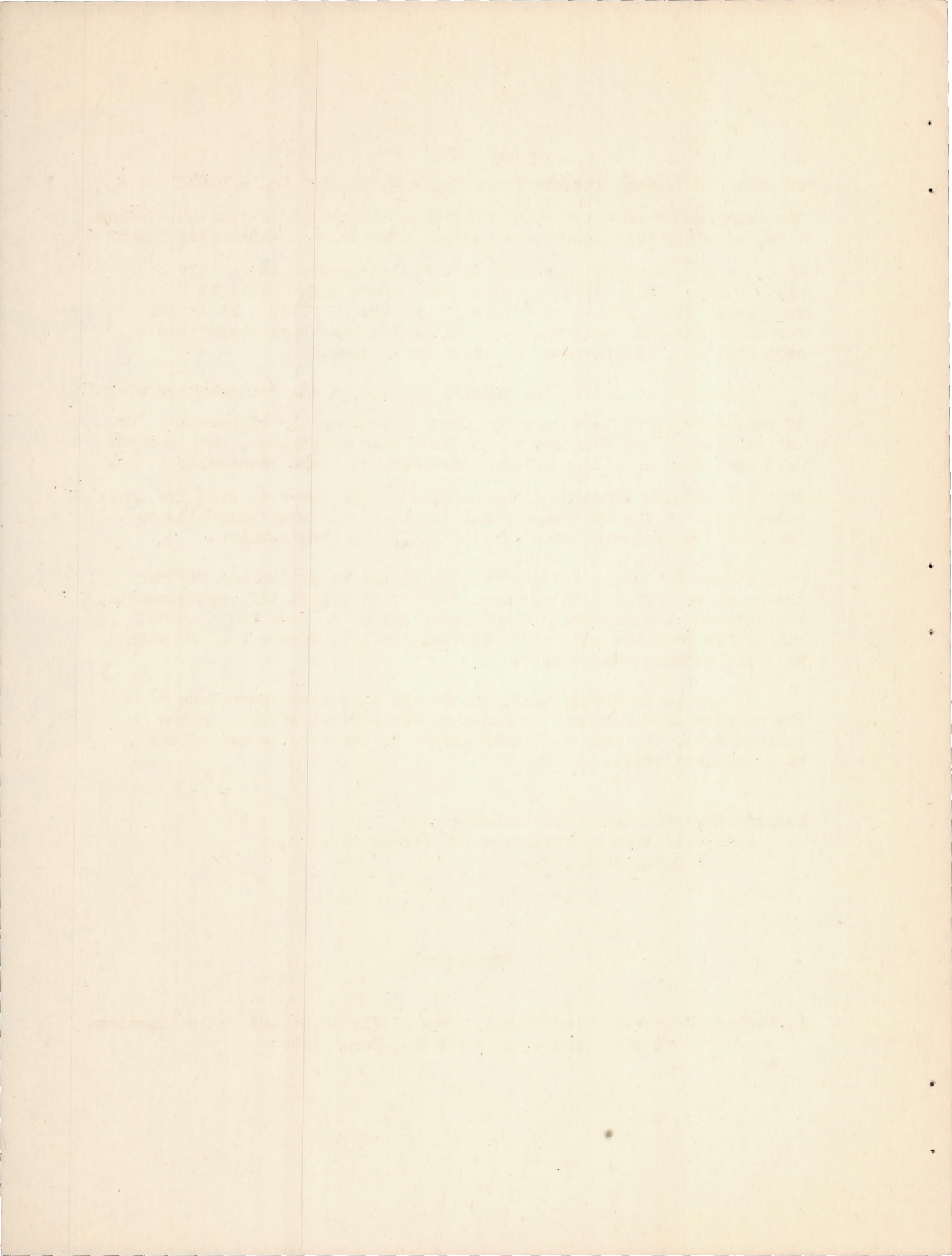
Figure 6 shows a lift comparison of the wing with and without the nacelle. Owing to a systematic error in tunnel lift measurements, the curve of the wing with the nacelle may be too low by an amount comparable with the separation between the lift curves for the wing with and without the nacelle.

It may be concluded that, unless the lift disturbance due to the nacelle is sufficient to cause marked adverse effects on the induced drag, the drag and interference of the nacelle tested may be considered small.

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#### REFERENCE

1. Becker, John V.: Wind-Tunnel Tests of Air Inlet and Outlet Openings on a Streamline Body. NACA A.C.R., Nov. 1940.





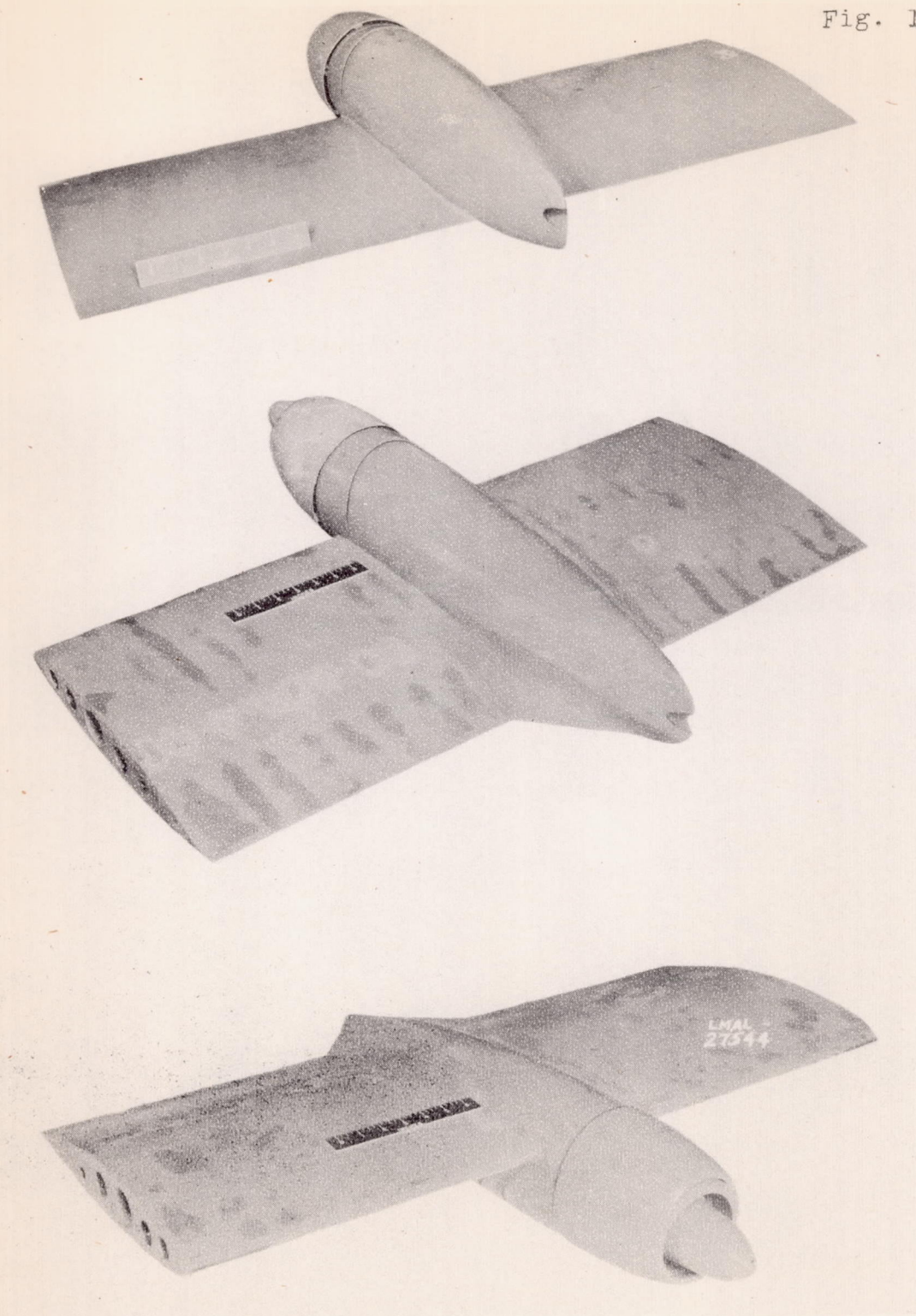
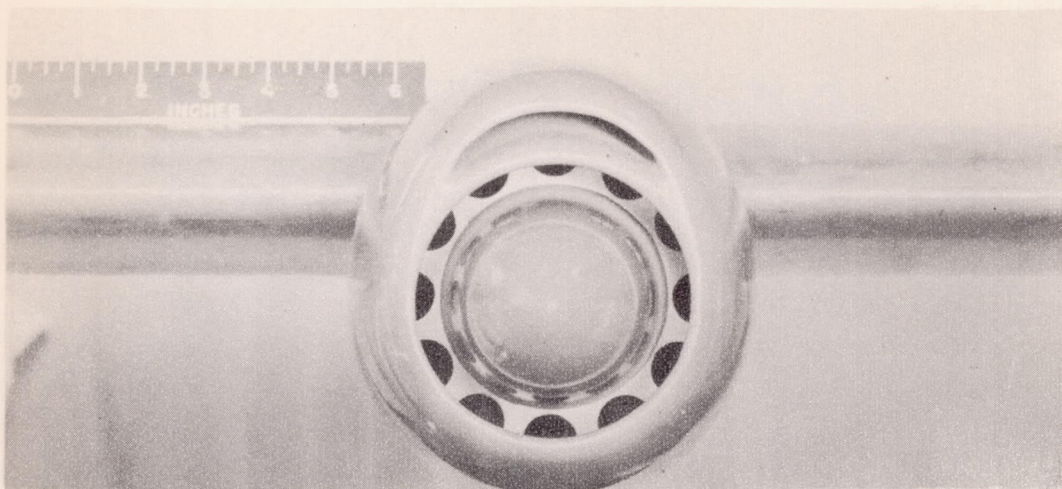
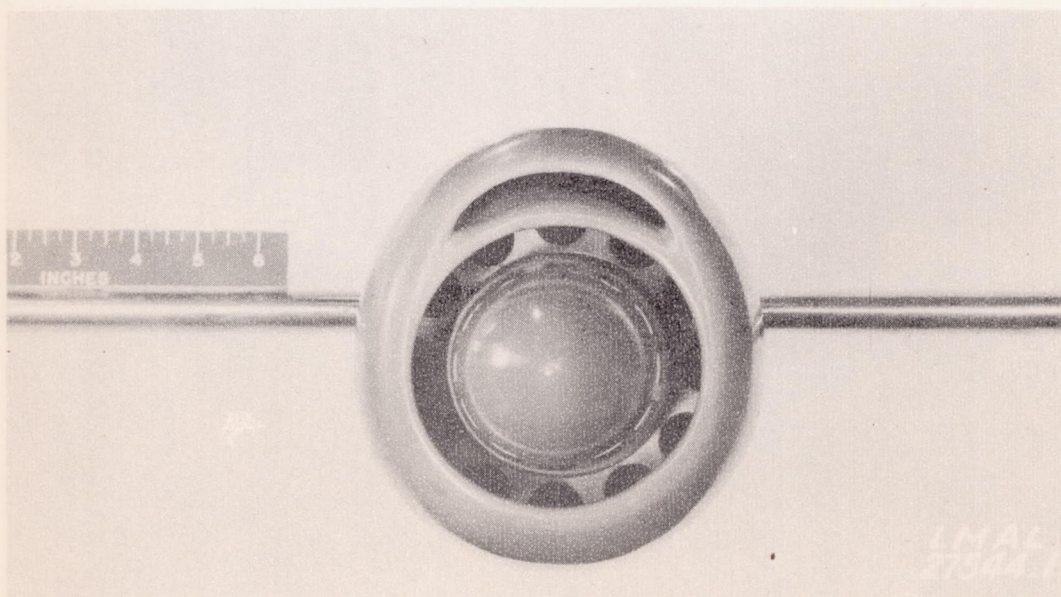


Figure 1. - Nacelle on low-drag wing.  
Accessory compartment exit slot and  
addition of ordinary tapered fillets  
are shown.



*Figure 2.- Nacelle on low-drag wing .*



*Figure 3.- Nacelle on 6 inch chord wing.*



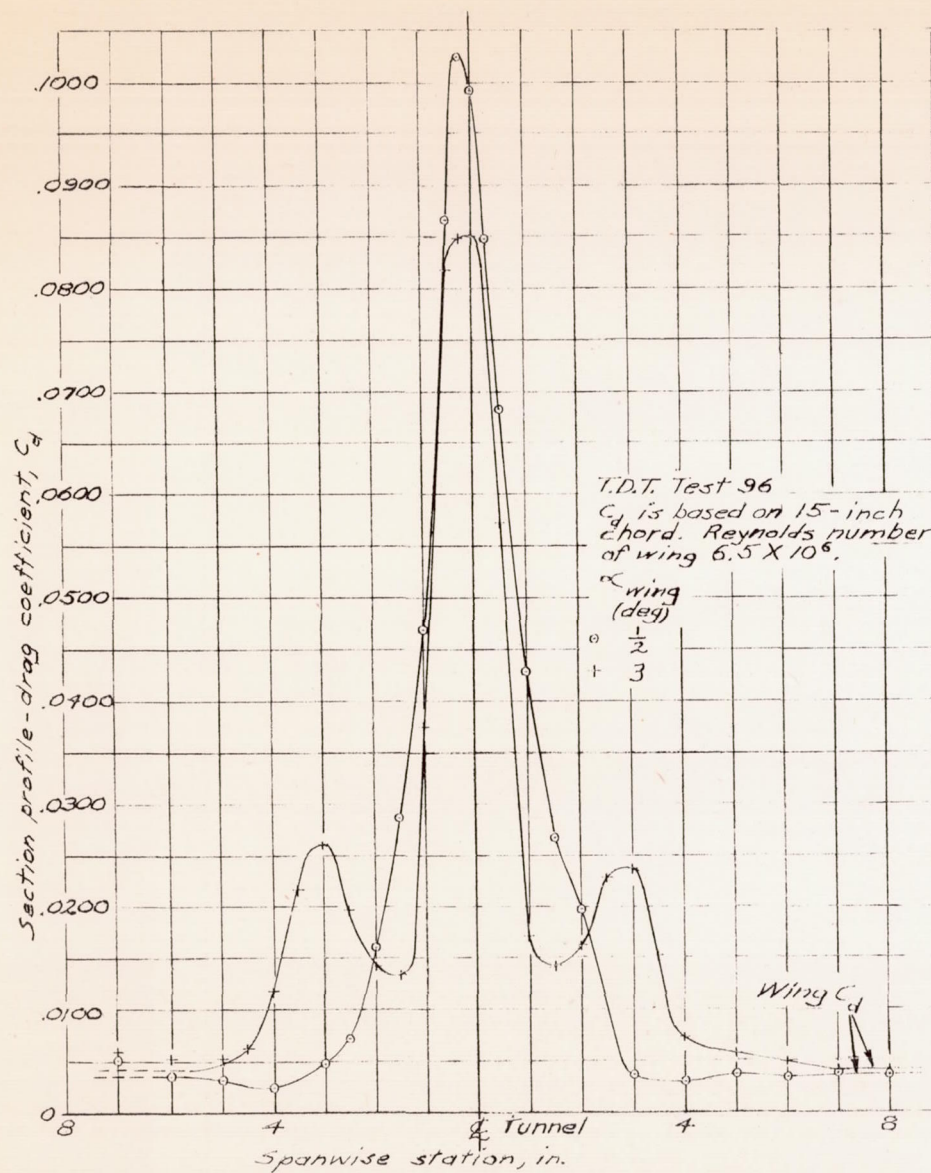
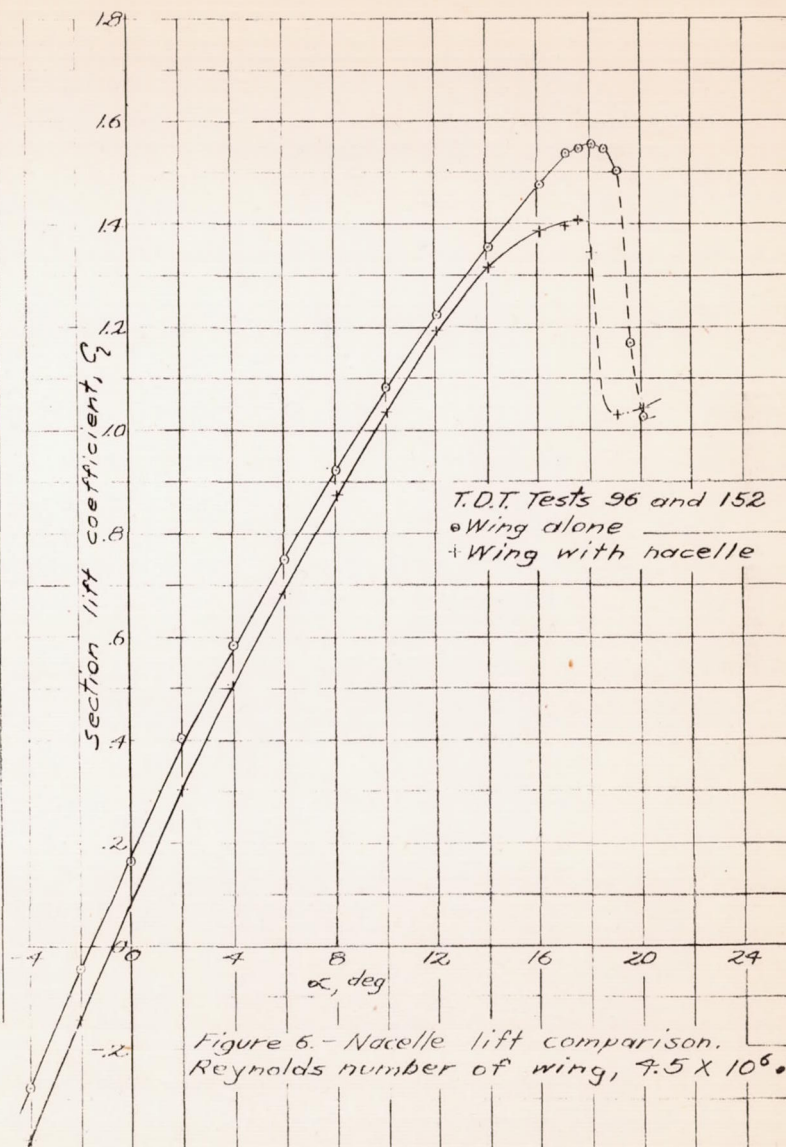


Figure 4.- Typical spanwise drag coefficient plot of nacelle on low-drag wing.



Nacelle is mounted  
 on 15-inch chord  
 NACA 66,2-216  
 $a = 0.6$  airfoil

$R_{wing}$   
 $3.1 \times 10^6$

$6.5 \times 10^6$

$6.5 \times 10^6$   
 based on  
 15-inch  
 chord

T.D.T. tests 96 and 138  
 {  $\Delta$  No fillets  
 {  $\times$  With ordinary tapered fillets  
 {  $\square$  With ~~same~~ fillets  
 {  $\diamond$  With fillets, accessory compartment  
 exit slot sealed  
 {  $\circ$  Nacelle mounted on 6-inch chord  
 symmetrical airfoil 12.5 percent  
 thick

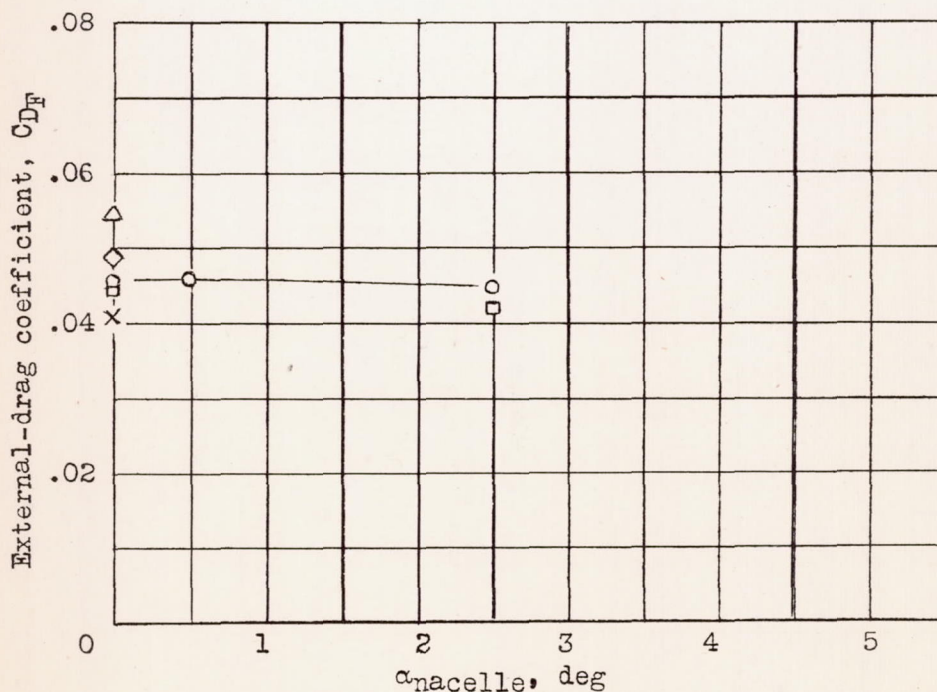


Figure 5.- Nacelle external-drag coefficients.